# Hamilton West Apartments Ecoroof

1212 SW Clay Street, Portland, OR

## **Project Summary**

Project Type:	Multi-family residential – demonstration project		
Technologies:	Ecoroof		
Major Benefits:	<ul> <li>Increased roof longevity – The ecoroof should double the life of the roof.</li> <li>Stormwater management – There is a substantial reduction in runoff from more than 8,400 sq. ft. of roof.</li> <li>Over the course of a typical year, the stormwater facilities manage about 768,000 gallons of potential stormwater assuming an average retention rate of 53.5% and an average annual rainfall of 37 inches.</li> <li>5,140 sq. ft. of landscaping was added, improving the urban environment and the aesthetic appeal of the property.</li> </ul>		
Cost:	\$127,500 (unit cost of \$15 per sq. ft. of impervious area managed). Environmental Services granted \$90,000 for the project.		
Constructed:	September 1999		

#### **Background**

In fall 1999, an ecoroof was installed on the newly constructed Hamilton West Apartments building. This was a joint project between the Housing Authority of Portland (HAP), the City of Portland Bureau of Environmental Services (BES), and the Portland Development Commission (PDC). It was the City's first ecoroof demonstration and testing facility. At Hamilton, the City measures stormwater capture and water quality and compares the success of planting methods, soil type and depth, and vegetation selection.

Hamilton and other ecoroofs represent an important sustainable stormwater (low impact development) strategy. They manage stormwater at the source, using natural systems that have positive impacts for stormwater runoff volume and quality. Associated benefits such as energy cost reduction, air pollution and heat reduction, bird and insect habitat, extended roof lifespan, and urban beautification, make ecoroofs a valuable urban asset.

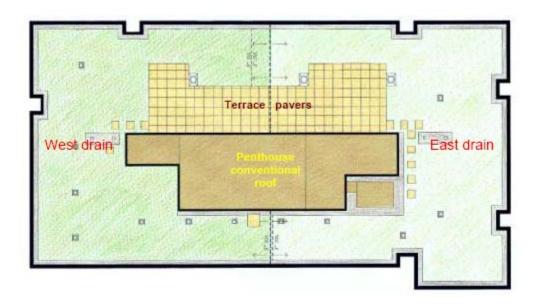


The 8,700 square foot roof is divided into an elevator vestibule (not vegetated), a 1,000 square foot concrete paver terrace with seating and tables, and a 5,140 square foot ecoroof containing succulents, grasses and flowers. The Hamilton Apartments ecoroof showcases opportunities for partnerships by public and private organizations and has served as a catalyst for other groups to pursue this method of stormwater runoff reduction. The building and roof terrace are an example

of how to maximize density on an urban infill site while providing outdoor amenities for tenants. Based on monitoring results, the ecoroof provides excellent stormwater management.

#### **Overview of the Stormwater System**

In order to test the stormwater capacity of different types and depths of soil, the ecoroof was divided into east and west sections. Each side was planted using identical methods and types of vegetation. The east side consists of 2,620 square feet of vegetated cover with initial substrate depth of 3 inches. Saturated weight is 10 pounds per square foot. The west side consists of 2,520 square feet of vegetated cover with initial soil substrate depth of 5 inches. Saturated weight is 25 pounds per square foot. There are two roof drains one in the west section and one in the east section. Each section slopes toward its roof drain.



The vegetated portion of the roof receives precipitation directly. Runoff from the stone terrace infiltrates through the pavers to the sand bed below and into the ecoroof substrate. Air conditioning condensate and runoff from the elevator vestibule is piped directly to the roof drain so that it does not skew stormwater measurement data.

## **Stormwater Capacity and System Components**

#### **Stormwater Management Goals**

The ecoroof is a demonstration project in stormwater management. It was designed to meet multiple goals and objectives that benefit tenants, partners, and the larger community. Goals include reducing peak flows and volume of stormwater, which helps alleviate Portland's combined sewer overflow (CSO) problem; and providing opportunities for research and education in development of ecoroof technology specific to the Pacific Northwest.

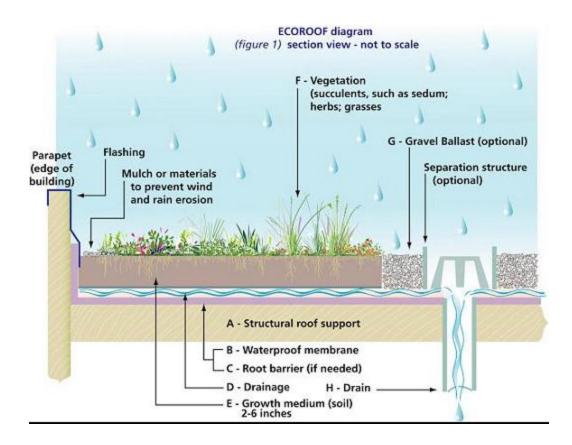
#### **System Components**

#### **Ecoroof**

Catchment area: 7,800 square feet Facility footprint: 5,140 square feet Overflow: Drains to storm sewers

Additional information:

- The roof is built in layers. From the bottom up, they are:
  - o A waterproofing membrane over the roof structure
  - o Root-resistant barrier made from 6 mm polyethylene
  - o A drainage layer made from a geotextile drainage fabric
  - o 1 cm thick Poly-scrim root reinforcement material
  - o Soil substrate (organic and coarse aggregate)
  - o Irrigation system
  - o Plants and walkway stones



Each side of the roof drains into a gravel filtering area then into a drainpipe inside the building that then connects to the City storm drain system. A small, 60 degree, V-trapezoidal flume is installed immediately upstream of each primary roof drain. A bubbler-type flow meter measures the water level at each flume. The primary roof drain is sealed and isolated to direct all flow through the flume prior to entering the drain. The possibility exists that during very large storms, some water may flow out the secondary drain and not flow through the flume.

#### **Emergency Overflow**

The primary roof drains are plumbed directly to the City storm sewer system. The secondary drains function as emergency overflow drains if the primary drains become plugged. Since the secondary drains are fitted with a two-inch extension collar, water enters the secondary drains only if the pooled water level around the drains exceeds the collar. The secondary drains discharge directly off the side of the building.

#### Landscaping

Each side of the roof was divided into three sections and planted identically using the following three methods. Plants include a mix of natives and hardy ornamentals.

- NE and NW sections planted with 11 x 22-inch (1.8 square foot) mats of pre-germinated seedlings and root cuttings
- West and east sections planted with plugs and containers of sedums, succulents, and perennials
- SE and SW sections planted with hand-broadcast mix of sedum sprigs, and hydro-seed matrix of perennial flowers and grasses. A small area of the south section was planted with native grasses and wildflowers such as lupine and yarrow.

#### Soil or substrate

The roof uses two types of substrate, one for the east side, and one for the west.

- The east side was installed with three inches of very lightweight mixture with a maximum saturated weight of 10 pounds per square foot.
- The west side was installed with five inches of lightweight mixture with a maximum saturated weight of 25 pounds per square foot.
- Lightweight soils erode easily. Because of soil loss due to wind, red pumice stone was
  added to the NE section. This treatment is now being measured to test its ability to
  control erosion, provide mineral content and pore space for plant roots, and suppress
  weeds.

#### **Irrigation**

The roof uses an automatic irrigation system with spray heads on 12-inch risers. Irrigation is applied each summer. In summer 2001, about 6 inches was applied to the east side and 4 inches to the west. After the initial plant establishment period, irrigation amounts were reduced. During the very dry summer of 2002, 3 inches of irrigation was applied to the east side and 2 inches to the west side.

Typically, irrigation is only used on the roof in limited amounts and when plants show effects from prolonged periods of dry, hot weather.

#### **Budget**

The final project budget submitted by the HAP was \$127,485 including management, design, materials and construction. The budget breaks down as shown below.

### **Budget Elements**

Activity	Cost	% of Total Cost
Design	\$17,900	14.0 %
Permitting	\$2,292	1.8 %
Roof Construction	\$43,620	34.2 %
Plantings	\$9,740	7.6 %
Soil and waterproof membrane	\$41,483	32.5 %
Irrigation	\$2,500	2.0 %
Miscellaneous	\$7,950	6.2 %
Total	\$127, 485	100 %

#### **Cost Comparisons**

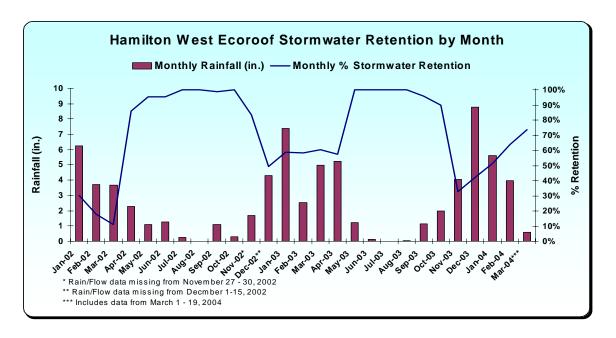
Because roofscaping covers and protects the waterproofing and structural components of a roof, ecoroofs typically last twice as long as conventional roofs. This means that in the long-term, higher construction costs are offset by lower repair and replacement costs.

The Hamilton West Apartments roof is designed as a building amenity and includes extra features not required for stormwater management. These include a terrace with tables, planters and seating, a fence separating this from the vegetated portion of the roof, and elevator access to the terrace. Additionally, the project was the first of its kind in Portland and required special attention.

This roof tested the effectiveness of different types of plant establishment. Techniques that were tested included installing grass sod and non-grassy sod, hydroseeding annuals and installing small plants by hand. A typical ecoroof would not include this research component and could choose the most cost-effective way of establishing the plants, rather than testing methods with a higher initial cost.

## **Maintenance and Monitoring**

The City is required to monitor the effectiveness of stormwater best management practices (BMP) per the City's National Pollutant Discharge Elimination System (NPDES) Stormwater Discharge permit. Flow monitoring and water quality sampling at the Hamilton ecoroof evaluates the stormwater management characteristics of this type of BMP and compares the relative effectiveness of the two different ecoroof soil types and depths. Monitoring for flow control, water quantity and water quality has been ongoing since 2000.

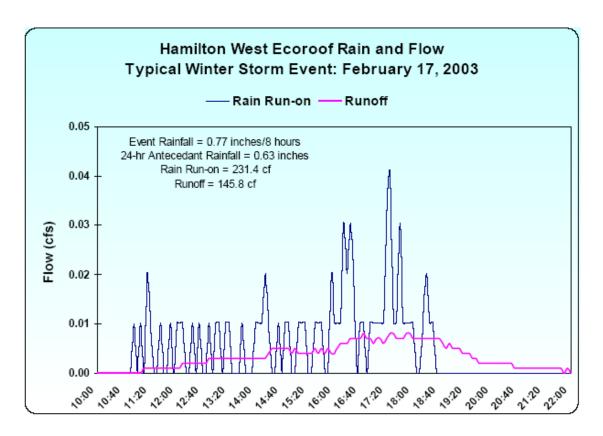


The chart above shows the seasonal variation in the percentage and amounts of stormwater that the ecoroof is able to manage. The columns show the amount of rainfall received during each month. The connecting line shows the percent of that rainfall that the ecoroof retains. As you can see from the rainfall columns, Portland has pronounced wet and dry seasons, which affects stormwater performance.

During dry months, the ecoroof retains and manages nearly all of the stormwater. This is important because runoff from a conventional roof during summer storms tends to contain more pollutants and will enter waterways at a higher temperature. During the rainy months, the ecoroof manages much higher volumes of water than the conventional roof. It eventually becomes saturated but even when it does not retain all of the water, it slows and filters the flow.

BES data show that the performance of the ecoroof is improving as the plants mature. During the first 16 months of monitoring, the ecoroof retained an average of 52.5% of all the rainfall it received. In the following 12 months, the roof retained 55.6% of the total rainfall, an improvement of 3%.

The next graph shows the performance of the ecoroof during a typical winter storm. You can see that the rainfall occurs in jagged spikes of differing intensity. Traditional roofs with drainpipe systems would discharge almost all of that water directly.



The smoother line on the chart represents the runoff from the ecoroof, as measured by the flow meters at the roof drains. As you can see, the sharp surges in rainfall are moderated. More than a third of the rain never flows out. The soil and the plants retain it. The rest of the runoff is delayed and slowly leaves the ecoroof even several hours later.

The City also evaluated the performance of the construction, soil, and plants installed on the roof. As of 2004, approximately one inch of soil had been lost on both sides of the roof due to wind erosion and soil decomposition. In late spring 2004, lightweight red pumice of less than ¾ inch size was applied to sparsely vegetated areas. This should prevent further wind erosion and allow an opportunity to observe any benefits to plant health from added mineral content and pore space for root growth.

Regular maintenance activities include the following components:

- About 1 inch of irrigation has been applied each summer during prolonged dry periods (typically ten or more days of no rain).
- The roof uses no fertilizers or herbicides. Hand weeding of the ecoroof occurs at least once a year in late spring.
- The owner of the property manages the terrace and accepts responsibility for all maintenance activities for the seating areas, planters, pavers, trash and the fence around the ecoroof. Periodic damage, primarily to the irrigation system, occurs from various human activities.

#### **Successes and Lessons Learned**

The Hamilton West Apartments ecoroof was one of the earliest ecoroof projects in the City of Portland. It has provided data on stormwater retention, plant cover establishment, cost factors, and substrate performance. Ongoing monitoring at the site continues to refine our knowledge of the performance and capabilities of the ecoroof.

After five years, the roof is beautiful and plant coverage has increased substantially from planting. Some species originally planted have died away, while others have spread rapidly. Certain plants that thrive on one side of the roof do less well on the other, highlighting the importance of selecting plants adapted to the conditions and depth of the soil. This data is helping the City develop a list of recommended ecoroof plant species and their growth requirements. The plants highlighted at the end of this section have proved particularly successful, and continue to spread and thrive on the roof habitat.

Before full plant coverage was established, wind erosion of soil occurred to a much greater degree than expected. About an inch of soil was lost from both sides of the roof. Care must be taken to protect the lightweight ecoroof soil from wind erosion or exposure. Early in 2004, lightweight pumice gravel was used to cover areas where soil was exposed in order to reduce further soil erosion. This technique seems to be successful. Plants are spreading through the gravel and birds do not expose underlying soil when they dig for insects.



Plants growing through red pumice

Water quality control tests reveal that elevated levels of certain metals are leaching from one of the two types of soils. This is one of the earliest studies of ecoroof water quality considerations, and these unexpected results show the value of experimentation and monitoring. Depending on water quality concerns in the area and the type of soil substrate used, it may prove useful to test the soil levels of materials of concern before installation.

The volume of water that the roof controls has increased as the plants on the roof have matured. Summer stormwater retention now reaches 100% and wet-season retention rates continue to increase. In a typical winter rain event, storm surges are eliminated and runoff release is delayed by about 4 hours. Delaying runoff that the roof cannot hold helps moderate flooding and combined sewer overflow events.

Other known benefits from the roof that have not been specifically quantified are reductions in ambient air temperature and building energy costs, increased urban habitat values for birds and other wildlife, and an open-space venue for the building tenants.

Residents frequent the roof terrace, particularly in sunny summer weather. It is an attractive and pleasant place and a considerable amenity to the building in a dense urban environment. This demonstration project has also shown the feasibility of this type of stormwater management practice, and many other projects in Portland have followed its example.

Soil monitoring shows that both very shallow and slightly deeper roof soils can support thriving plant communities. Very shallow soils are most favorable to sedum species and showed more bare areas than the deeper soil on the west side. Care must be taken in preventing wind erosion in very shallow soils, as erosion can easily expose the underlying drainage layers in areas without plant coverage.

The slightly deeper soil on the West side of the roof shows greater plant coverage, but also has greater problems with weeds. Weedy plants such as vetch and red clover each cover up to 30% of the roof's west side. Most of the roof plants are low growing and these plants can grow right over them. Areas where taller grasses are established seem more able to resist weeds.

More than 40 types of plants grow on the Hamilton ecoroof. Some plants clearly prefer the deeper soil on the west side of the roof, and some do better on the thinner soil on the east side. These lists show currently predominant plants on each side of the roof, in order of their prevalence. Many other plants are also present in trace amounts. You can find a more complete discussion of ecoroof vegetation in the document *Plant Survival Findings in the Pacific Northwest*, published by the City of Portland Bureau of Environmental Services in summer 2005.

West side dominants (deeper soil)	East side dominants (shallow soil)
Blue Fescue (Festuca glauca)	Spanish stonecrop (Sedum hispanicum)
Cascade stonecrop (Sedum divergens)	Kirin-so (Sedum kamtschaticum)
Iceplant (Delosperma cooperii)	Iceplant (Delosperma cooperii)
Spanish stonecrop (Sedum hispanicum)	Redstem filaree ( <i>Erodium cicutarium</i> )
Common thyme ( <i>Thymus vulgaris</i> )	Dragon's blood (Sedum spurium)
Dragon's blood (Sedum spurium)	Oregon stonecrop (Sedum oreganum)

The following sampling of species have spread and thrived particularly well. They represent a mix of native and ornamental plants. These plants are very hardy and should do well in most roof garden settings. Monitor plants closely immediately after planting, as the initial establishment period is the most difficult time for the plant.

**Kirin-so:** *Sedum kamtschaticum* This type of stonecrop was included in the vegetated mats placed on the North sections of the roof during initial planting. This is a perennial plant. Bright green leaves turn red in October before going dormant. New growth begins in March. Growing habit is compact, upright and spreading. Kirin-so has yellow flowers from June through early November and reaches less than 6 inches in height.



**Iceplant:** *Delosperma cooperii* Both red and purple varieties of this ornamental plant grow on the Hamilton ecoroof. Most of the red variety died back during a prolonged cold spell in January 2004. These plants are noted for thriving particularly well near air exhaust vents, which can ordinarily be a very stressful environment for plants. They form low, creeping mats around six inches in height, with bright green vegetation and conspicuous flowers. Flowers begin in summer and persist through mid-winter.



**Spanish stonecrop:** *Sedum hispanicum var. minus* This stonecrop species is most prevalent on the south portions of the ecoroof, where it was covered with the hydro-seed mix of the initial planting. Spanish stonecrop has a spreading habit, and forms a dense, creeping mat of gray-green leaves. Pale pink flowers bloom from July through August. Spanish stonecrop reaches between 4 and 6 inches in height.



**Blue fescue:** *Festuca glauca* Blue fescue is a perennial grass that was included in the vegetated mats from the original planting. Blue fescue is a persistent spreader and grows about 14 inches high. It is located primarily in the north sections, especially on the west side where the soil is deeper (5 inches deep rather than 3). The grass grows in bunches of fine, bluish-green leaves. Some outer leaves brown out in the fall. Blooms observed in late April.



Common thyme: *Thymus vulgaris* Common thyme has an upright, bushy growing habit and reaches about 8 to 10 inches in height. This plant showed stress immediately after the initial planting and experienced some dieback, but those plants that survived the first year are now vigorous and spreading slowly.

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